AN INCENTIVE CONTRACT WITH ASYMMETRIC INFORMATION

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This paper considers the problem of designing an optimal incentive contract between a retailer and a manufacturer when the former has private information about demand and its own cost. Based on a multi-period framework, we show that the incentive franchise contract can bring about the first-best outcome of vertical integration when the retailer has complete information about consumers' preferences. [L42, D8]

1. INTRODUCTION

The problem of double marginalization (or chain-of-monopolies) has been widely recognized as an effective way to justify the phenomenon of vertical integration or restraints between upstream and downstream firms. More specifically, with some vertical instruments such as franchise fee contract and resale price maintenance contract, a manufacturer can effectively curb the incentive of a retailer to put a monopoly mark-up on final products (e.g. Bresnahan and Reiss, 1985; Mathewson and Winter, 1983, 1984, 1985). Mathewson and Winter (1983, 1984) explain why contractual provisions such as resale price maintenance or territorial protection are sometimes used, and extend the basic model to include service promotion and advertising. Rey and Tirole (1986) describe contracts between a monopoly manufacturer and competitive dealers who are symmetrically informed at the time of contracting, and analyze private and social incentives for the use of various types of vertical restraints. Rey and Stiglitz (1988) show that vertical restraints may serve to

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facilitate collusion when upstream firms are imperfectly competing. Perry and Besanko (1991) illustrate that manufacturers may impose price ceilings when competing for retailers. O’Brien and Shaffer (1992) show that when retailers cannot observe their rival’s contracts, incentives to choose each contract to maximize bilateral profits may yield retail prices well below the vertically integrated level.

However, these arguments may be invalid in certain situations, especially when information is asymmetric between the manufacturer and the retailer. For instance, if the retailer has private information about his own cost conditions, the manufacturer has no way to calculate a proper level of franchise fee or to set a desired resale price to be maintained. Moreover, in vertical relationships, manufacturer usually relies on retailer to supply advertising or product demonstration service to market his goods, which is in general also private information. Therefore, neither the cost level of service supplied by the retailer nor the state of demand can be observed by the manufacturer. Then, there may exist a moral hazard problem.

When the retailer has private information about not only his own cost condition but also consumers’ preferences structure, the literature has justified employing several efficient ways of franchise fee, resale price maintenance, or quantity rationing. The model in Gal-Or (1991), Romano (1994), and Blair and Lewis (1994), for example, is the simplest extension of the successive-monopoly model that accommodates these issues. Gal-Or (1991) examines the problem within a Bayesian framework with a truthful reporting scheme and shows that informational asymmetry would not allow achieving the first-best outcome of vertical integration. Romano (1994) examines that resale price maintenance is generally part of the optimal contract and helps resolve the vertical externalities. Blair and Lewis (1994) derives the constrained joint-profit-maximizing retail contracts when the retailer is privately informed about demand conditions and shows that the optimal contract exhibits some form of resale price maintenance and quantity fixing.

The incentive vertical contract of the successive-monopoly model in the presence of asymmetric information and moral hazard is the subject of this article. In this paper, we suggest an incentive franchise contract in a multi-period framework when the retailer is privately informed about demand and cost conditions before contracting with the manufacturer. In the model, demand depends on price, the quality level of intermediate good supplied by the manufacturer, and the level of promotion chosen by the retailer. Specifically, we imagine an efficient multi-period contract in which the manufacturer allows the privately informed retailer to utilize his own superior information by delegating the choice of promotional effort and retail price but the manufacturer can enforce the retailer to offer a special menu of price, and quality should be provided based on the previous outcome. The retailer retains all sales revenue, but he must pay the manufacturer a franchise fee for the goods that he markets. It is shown that
the suggested contract that stipulates franchise fee and resale price maintenance can bring about the first-best outcome of vertical integration.

The remains are the organization of the study. In Section 2, we specify the basic model. In Section 3, we propose an optimal contract under asymmetric information where the retailer has complete information about consumers' preferences. Final section concludes the discussion.

2. THE BASIC MODEL

Consider a vertical structure of bilateral monopolists, a manufacturer and a retailer, with fixed-proportion production technology: the manufacturer is the only producer of the good and he sells it as an intermediate input to a single downstream firm, the retailer, who processes and sells it to consumers.\(^1\) Formally, after signing the contract, the retailer has a monopoly on a technology that transforms one unit of the intermediate good into one unit of the final good that is indivisible. We consider a durable product that may be differentiated on “quality” dimension on which consumers agree in their preference ordering (see Romano, 1994).

Let the manufacturer’s quality level be denoted by \(q\). The manufacturer’s cost function is given by \(C(q)\) where \(C'(q) > 0\) and \(C''(q) \geq 0\). Retailer provides services that make the manufacturer’s good more attractive to consumers.\(^2\) Promotional effort or services of the retailer can be formalized as \(s\). We assume that supplying a level of \(s\) of services costs the retailer \(\varphi(s)\) per unit of output where \(\varphi'(s) > 0\) and \(\varphi''(s) \geq 0\). Then, the total quality of the final good \(x = x(q,s)\) where \(\partial x / \partial q > 0\), \(\partial x / \partial s > 0\) and \(\partial q / \partial s = 0\).

On the demand side, we assume that there are \(m\) types of consumers and each consumer has unit demand. Let the preference of type \(\theta_i\), consumer be described by

\[
U_i(x, P) = \theta_i V(x) - P, \quad i = 1, \ldots, m.
\]

if she consumes one unit (of quality \(x\)) and pays \(P\), and by 0 otherwise. Here, \(\theta_i (> 0)\) is the taste parameter. We assume that the number of \(\theta_i\) consumers is \(n_i\).

\(^1\)This assumption makes us investigate whether more sophisticated contracts can resolve the agency problem. For the literature, see Gal-Or (1991), Romano (1994), and Blair and Lewis (1994).

\(^2\)This includes, for example, advertising, product demonstration, point-of-sale service, and so on. Relying on retailers is thought to be important for automobiles, clothes, stereo and television equipment, and home furnishings.
which is common knowledge. We also assume that $V(x) > 0$, $V''(x) \leq 0$.

Before the contract is signed, the retailer has private cost condition, $o(s_i)$, and knows the consumer’s preference structure, $\theta_i$, and $V(x)$. However, the manufacturer does not know these. All he can observe is the current market price together with the ex-post realized quality level $(P_i, x_i)$ proposed to consumers and the retailer’s total expenditures, $E$, with a time lag of one period. Total expenditures may exceed the minimal effort cost by the moral hazard cost $w$. That is,

$$E = \sum_{i=1}^{m} n_i \phi(s_i) + w.$$

The possibility of the retailer engaging in moral hazard is considered in order to determine whether the retailer has an incentive to behave strategically to overstate his costs under the franchise contract.\(^3\)

As a benchmark, we first consider the first-best situation of vertical integration, in which the firm maximizes the aggregate profit, the sum of the manufacturer’s and the retailer’s profits, under the constraints of consumers’ market participation:

$$\max_{\{q_i, s_i, P_i\}} M = \sum_{i=1}^{m} n_i [P_i - \phi(s_i) - C(q_i)]$$

s.t. $U_i(x_i; P_i) \geq 0$, $i = 1, \ldots, m$.

Then, the objective can be rewritten as follows:

$$\max_{\{q_i, s_i, \theta_i\}} M = \sum_{i=1}^{m} n_i [\theta_i V(x_i) - \phi(s_i) - C(q_i)]. \quad (1)$$

Assuming that a unique maximum exists, the necessary conditions for the vertical

\(^3\)Romano (1994) and Blair and Lewis (1994) addressed the issue of moral hazard in demand side.
integration are:

$$\frac{\partial M}{\partial q_i} = \theta_i V'(x_i) \frac{\partial x_i}{\partial q_i} - C'(q_i) = 0, \quad (2)$$

and

$$\frac{\partial M}{\partial s_i} = \theta_i V'(x_i) \frac{\partial x_i}{\partial s_i} - \phi'(s_i) = 0, \quad i = 1, \ldots, m. \quad (3)$$

Let \( x_i^F = x_i(q_i^F, s_i^F) \) be the first-best outcome of vertical integration, where marginal benefit equals marginal cost. Notice that if the manufacturer and the retailer are vertically integrated, then the integrated entity will produce a good with \( x_i(q_i^F, s_i^F) \) and charge \( P_i = \theta_i V(x_i^F) \) to completely extract the surplus.

3. AN EFFICIENT VERTICAL CONTRACT WITH ASYMMETRIC INFORMATION

Suppose now that the manufacturer and the retailer are separated, and that the manufacturer wishes to obtain the outcome of vertical integration, specified in (2) and (3), under an asymmetric information situation where the manufacturer does not know either the cost function of the retailer or consumers' preferences.

The efficient contract structure in a multi-period framework is as follows: Before contracting, the manufacturer specifies each consumer type's quality level of the intermediate good, \( q_i^0 \), and the retailer's promotion level of the product, \( s_i^0 \), in period 0. Namely, the manufacturer stipulates the quality level of the product \( x_i^0 \) for each type of consumers. Let the initial expenditures the retailer spends for the initial services \( s_i^0 \) be \( E^0 \). Now we assume that they enter into a multi-period franchise contract in period 1. From period 1, the retailer has to offer a menu in which he provides the quality supplied in the previous period. That is, in period \( t (\geq 1) \), the retailer should offer a menu of \( (x_i^t, \bar{P}_i^t) \) where the retailer can also choose \( \bar{P}_i^t \) at will. In addition, the retailer can offer his own menu \( (x'_i, \bar{P}'_i) \) intended to be chosen by each consumer, if he desires. Under the
contract, the retailer can choose the quality level of the intermediate good, \( q'_i \), by requesting to manufacturer. On the other hand, when the manufacturer supplies \( q'_i \), he imposes a franchise fee of \( T' = A + \sum_{i=1}^{m} n_i C(q'_i) \), where \( A = (1 - \gamma ) \left( \sum_{i=1}^{m} n_i (\bar{P}'_i - C(q'_i)) - E't' \right) \) and \( \gamma \) is a positive number in \((0,1)\), on the retailer.

Then, the objective of the retailer under the contract is to maximize the present value of all future profits:

\[
\max_{\{a'_i, s'_i, w'_i, P'_i, \bar{P}'_i, t'\}} \quad R = \sum_{i=1}^{\infty} \beta^t \left( \sum_{i=1}^{m} n_i P'_i - E'_t - T'_t \right) \tag{4}
\]

s.t.

\[
T'_t = (1 - \gamma ) \left( \sum_{i=1}^{m} n_i (\bar{P}'_i - C(q'_i)) - E't' \right) + \sum_{i=1}^{m} n_i C(q'_i) \tag{5}
\]

\[
E'_t = \sum_{i=1}^{m} n_i \phi(s'_i) + w'_t \tag{6}
\]

\[
\theta_i V(x'_i) - P'_i \geq 0 \tag{7}
\]

\[
\theta_i V(x'_i) - P'_i \geq \theta_i V(x'^{t-1}_i) - \bar{P}'_i \tag{8}
\]

where \( \beta \) in \((0,1)\) is the discount factor. Notice that the constraint in (7) is the individual rationality or the market participation constraint for consumers. Notice also that the constraint in (8) is the newly introduced incentive compatibility constraint induced by the incentive contracts. It implies that if the retailer desires to offer his own menu \((x'_i, P'_i)\) and wants each consumer to choose his menu rather than \((x'^{t-1}_i, \bar{P}'_i)\), the constraint in (8) should be satisfied.

**PROPOSITION 1.** The efficient contract leads to an outcome with
(i) cost efficiency of the retailer; \( w'_t = 0 \) for all \( t > 0 \).
(ii) the first-best outcome of vertical integration; \( q'_i = q'^{t}_i, s'_i = s'^{t}_i \) for all \( t \geq 1 \).
PROOF: (i) Substitute (5) and (6) into the objective in (4). It is noteworthy that $R$ is a decreasing function in $\tilde{P}_i^t$ and an increasing function in $P_i^t$. From (7) and (8), it is easy to show that

$$\tilde{P}_i^t = P_i^t - \theta_i V(x_i^t) + \theta_i V(x_{i-1}^t) \text{ and } P_i^t = \theta_i V(x_i^t).$$

This results in $\tilde{P}_i^t = \theta_i V(x_{i-1}^t)$. Substituting them into the maximization problem in (4), it becomes

$$\max_{|q_i^t, s_i^t, w_i^t|} R = \sum_{i=1}^{\infty} \beta^i Z(q_i^t, s_i^t, w_i^t) - (1 - \gamma)Z(q_{i-1}^t, s_{i-1}^t, w_{i-1}^t), \quad (9)$$

where $Z(q_i^t, s_i^t, w_i^t) = \sum_{i=1}^{n} n_i \theta_i V(x_i^t) - \phi(s_i^t) - C(q_i^t) - w_i^t$.

Thus, the necessary conditions for a solution of the maximization problem with respect to $w_i^t$ are:

$$\frac{\partial R}{\partial w_i^t} = -\beta^i [1 - \beta(1 - \gamma)] \leq 0 \text{ and } \frac{\partial R}{\partial w_i^t} w_i^t = 0.$$

Since $\beta$ and $\gamma$ are in $(0, 1)$, it follows that $w_i^t = 0$ for all $t \geq 0$.

(ii) Assuming that the maximization problem has an interior solution and the second-order conditions hold, differentiating the objective in (9) with respect to $q_i^t$ and $s_i^t$ gives:

$$\frac{\partial R}{\partial q_i^t} = \beta^i [1 - \beta(1 - \gamma)] \left( \theta_i V'(x_i^t) \frac{\partial x_i^t}{\partial q_i^t} - C'(q_i^t) \right) = 0.$$

and
\[
\frac{\partial R}{\partial s_i^t} = \beta'[1 - \beta(1 - \gamma)]\left(\theta_i V'(x_i^t) \frac{\partial x_i^t}{\partial s_i^t} - \phi'(s_i^t)\right) = 0, \quad i = 1, \ldots, m.
\]

Since \(\beta\) and \(\gamma\) are in \((0,1)\), the retailer will behave in such a way that realizes the first-best outcome in (2) and (3) with \(q_i^F\) and \(s_i^F\) for all \(t \geq 1\). Q.E.D.

**PROPOSITION 1.** suggests that under the assumption that it is profitable for the retailer to enter into the contract, the efficient contract induces the retailer to voluntarily realize the first-best outcome of vertical integration. In order to confirm that the efficient solution in proposition 1 is really an interior one, it suffices to show that the discounted sum of all future earnings is greater than that of no contract. The next proposition shows that the present contract guarantees nonnegative profits to the retailer.

**PROPOSITION 2.** Under the efficient contract, the retailer can earn nonnegative profits.

**PROOF:** From the equation in (9) and the results in Proposition 1, we have

\[
R = \sum_{t=1}^{\infty} \beta^t [Z(q_i^t, s_i^t) - (1 - \gamma) Z(q_i^{t-1}, s_i^{t-1})],
\]

\[
= \beta [Z(q_i^F, s_i^F) - (1 - \gamma) Z(q_i^0, s_i^0)] + \gamma Z(q_i^F, s_i^F) \beta^2 / (1 - \beta)
\]

where \(Z(q_i^0, s_i^0)\) represents total social surplus, which is nonnegative, and \(Z(q_i^F, s_i^F)\) is the maximized social surplus. It implies that \(Z(q_i^F, s_i^F) \geq Z(q_i^0, s_i^0) \geq 0\). Since \(\beta\) and \(\gamma\) are in \((0,1)\), the retailer can earn nonnegative profits under the contract and thus, will enter into the contract. Q.E.D.

4. **DISCUSSIONS**

The propositions carry some interesting economic implications. First, the objective of the retailer under the contract is given in (9), where \(Z(q_i^t, s_i^t)\) is equivalent to \(M\) in (1), which is the aggregate profits of vertical integration. Thus, the retailer's profit in each period is related with the increment in total aggregate profits. That is, the efficient contract is a profit-sharing scheme: this
scheme characterizes the constrained aggregate-profit-maximizing retail contract and, thus the retailer ensures that total aggregate profits are maximized in each period under the contract. Therefore, even though the retailer may choose a different strategic behavior, the best strategy of the retailer is to offer \((x_i^F, \theta V(x_i^F))\) immediately in period 1 and then to maintain the level thereafter.\(^4\)

This indicates that the efficient contract induces the retailer to voluntarily realize the first-best outcome of vertical integration.

Specifically, the realized aggregate profits, 
\[
Z(q_i^F, s_i^F) = \sum_{j=1}^{m} n_j \theta V(x_i^F) - \phi(s_i^F) - C(q_i^F),
\]
are the maximized total social surplus from period 1. This surplus is distributed only between the manufacturer and the retailer according to the size of \(\gamma\) while no surplus goes to the consumers. Thus, \(\gamma\) can be interpreted as the profit-sharing factor between the manufacturer and the retailer. Notice that the retailer’s profit \(R\) is increasing function of \(\gamma\), where \(0 \leq \gamma \leq 1\). For example, if we consider the limiting case when \(\gamma\) approaches 0 in (9), then manufacturer collects the franchise fee of \(Z(q_i^0, s_i^0)\) in period 1 and \(Z(q_i^F, s_i^F)\) thereafter while the retailer earns \(Z(q_i^F, s_i^F) - Z(q_i^0, s_i^0)\) in period 1 and zero in later periods. That is, the retailer earns exactly the increment in aggregate profits between the initial period and period 1, \(R = \beta Z(q_i^F, s_i^F) - Z(q_i^0, s_i^0)\), which is certainly nonnegative. This is so because \(Z(q_i^F, s_i^F)\) is the maximum value.

This interpretation makes us consider a setting in which there is competition in the upstream (or downstream) market.\(^5\) In the competition case, the retailer seeks more (or less) reservation profits. Then, under the optimal contract there can be communication and bargaining between the manufacturer and the retailer to adjust profit-sharing rule. As a simple extension, for example, if there is a perfect competition in the upstream market, the manufacturer should guarantee positive profit to the retailer. Then, from (10), we have

\[
R = \beta Z(q_i^F, s_i^F) - Z(q_i^0, s_i^0) + \gamma \beta Z(q_i^0, s_i^0) + Z(q_i^0, s_i^F) \beta^2 / (1 - \beta).
\]

\(^4\)These results are very similar in spirit to those set out by the multi-period incentive mechanisms in the optimal, optional regulation of natural monopoly, under which the regulator induces the firm to move to the first-best optimum over time. See, for example Sibley (1989), Kim and Jung (1995), and Lee (1997).

\(^5\)In the literature, several important works have discussed this issue. See, for example, Rey and Tirole (1986), Rey and Stiglitz (1988), Perry and Besanko (1991), and O’Brien and Shaffer (1992) among others.
Denoting the reservation profit under the situation of upstream competition as \( R^U \geq 0 \), the manufacturer can adjust the size of \( \gamma \) to satisfy \( R \geq R^U \) or

\[
\gamma \geq \frac{R^U - \beta Z(q^F_i, s^F_i) - Z(q^0_i, s^0_i)}{\beta Z(q^0_i, s^0_i) + Z(q^F_i, s^F_i)\beta^2 / (1 - \beta)}.
\]

It is noteworthy that in the process of the efficient contract, the newly introduced menu of \( (x^{t-1}_i, \tilde{P}^t_i) \), as a quality fixing and resale price maintenance, plays a critical role in nullifying the strategic interest of the retailer, even though it is not chosen by the consumers.\(^6\) As a matter of fact, the retailer offers two options: an existing option \( (x^{t-1}_i, \theta_i, V(x^{t-1}_i)) \) and a new option \( (x^t_i, \theta_i, V(x^t_i)) \) to type \( \theta_i \) consumers. Consumers may choose a new good as an option rather than as a substitute for the existing option. Therefore, if a new option is offered, then consumers who would be hurt under the new option can choose to stay on the existing option. This implies that the contract utilizes the consumers’ self-selection property under the asymmetric information of demand.

Finally, the retailer will not engage in spending moral hazard expenditures from the initial period because \( w \) is returned to her as the discounted amount of \( \beta (1 - \gamma) w \), which is certainly less than \( w \), in later periods. This also implies that the contract includes partial compensation for expenditures under the asymmetric information of cost.

5. CONCLUDING REMARKS

We have attempted to model the important information asymmetries in vertical relationships where the retailer has private information about his own cost condition and consumers’ preference structure, and characterized an incentive vertical contract with a franchise fee and resale price maintenance. Based on a multi-period framework, we have shown that the incentive franchise contract can bring about the first-best outcome of vertical integration when the retailer has complete information about consumers’ preferences. The key to an efficient contract is for the manufacturer to utilize consumers’ self-selection. The vertical restraints with the proposed sophisticated contract can effectively curb an

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\(^6\)In fact, in period 1, two options \( (x^0_i, \theta_i, V(x^0_i)) \) and \( (x^F_i, \theta_i, V(x^F_i)) \) are offered but only the latter is chosen by consumer \( i \) and, from period 2 onward, only a single option \( (x^F_i, \theta_i, V(x^F_i)) \) is offered to consumer \( i \).
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incentive of a monopolistic retailer of putting a monopoly mark up on final products without moral hazard problem.

A promising extension of this approach would be to verify whether the results still hold when demand or cost uncertainty is incorporated (see, for example, Rey and Tirole, 1986). A conjecture is that in order to share risk efficiency, there would be a more added incentive or risk premium to engage in an incentive contract. This rather challenging issue is left for future research.

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